Figure 1A

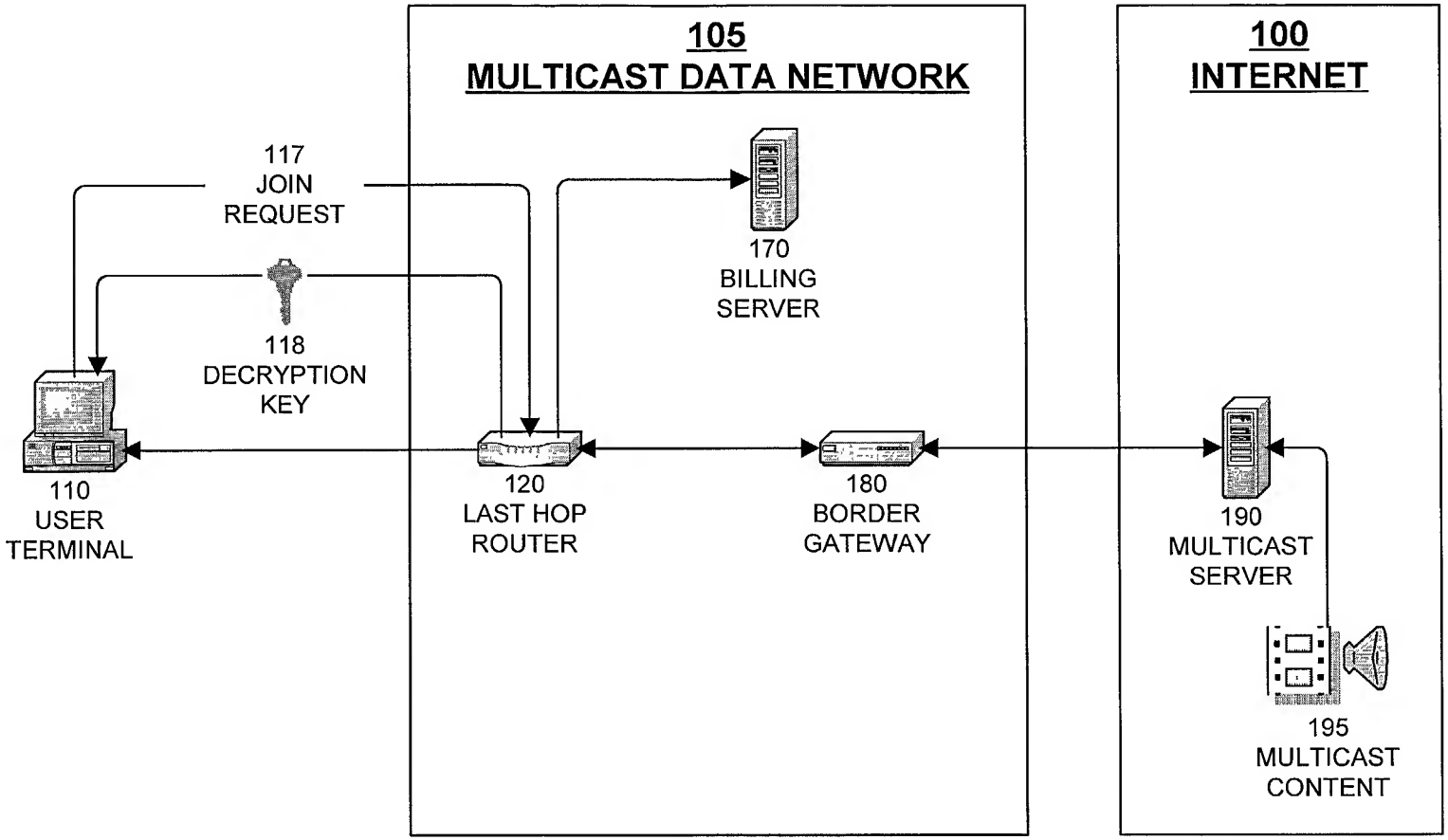

105
MULTICAST DATA NETWORK
100
INTERNET
117
JOIN
REQUEST
170
BILLING
SERVER
118
DECRYPTION
KEY
110
USER
TERMINAL
120
LAST HOP
ROUTER
180
BORDER
GATEWAY
190
MULTICAST
SERVER
195
MULTICAST
CONTENT

Figure 1B

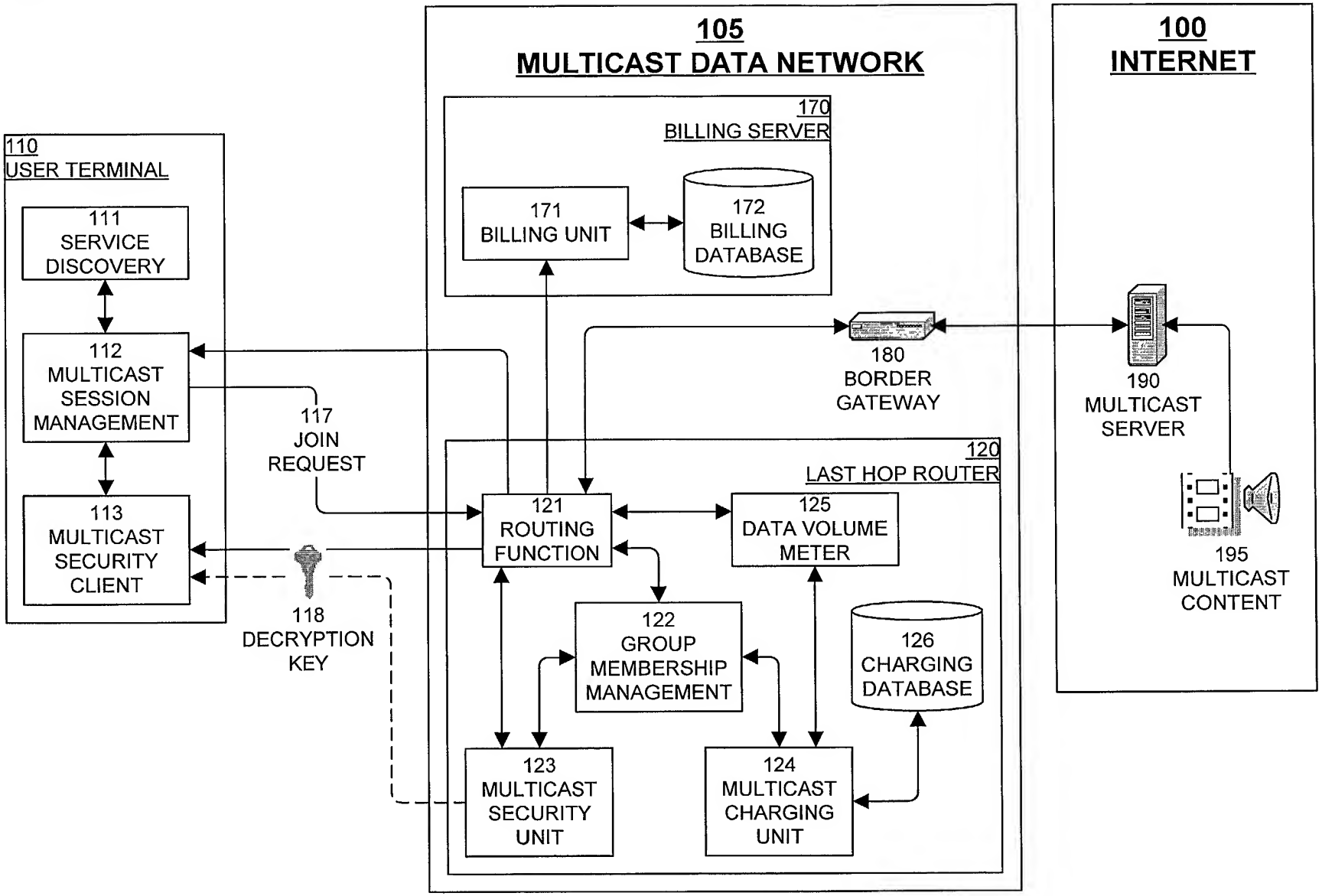

105
MULTICAST DATA NETWORK
100
INTERNET
170
BILLING SERVER
171
BILLING UNIT
172
BILLING
DATABASE
110
USER TERMINAL
111
SERVICE
DISCOVERY
112
MULTICAST
SESSION
MANAGEMENT
113
MULTICAST
SECURITY
CLIENT
117
JOIN
REQUEST
118
DECRYPTION
KEY
180
BORDER
GATEWAY
190
MULTICAST
SERVER
195
MULTICAST
CONTENT
120
LAST HOP ROUTER
121
ROUTING
FUNCTION
125
DATA VOLUME
METER
122
GROUP
MEMBERSHIP
MANAGEMENT
126
CHARGING
DATABASE
123
MULTICAST
SECURITY
UNIT
124
MULTICAST
CHARGING
UNIT

Figure 1C

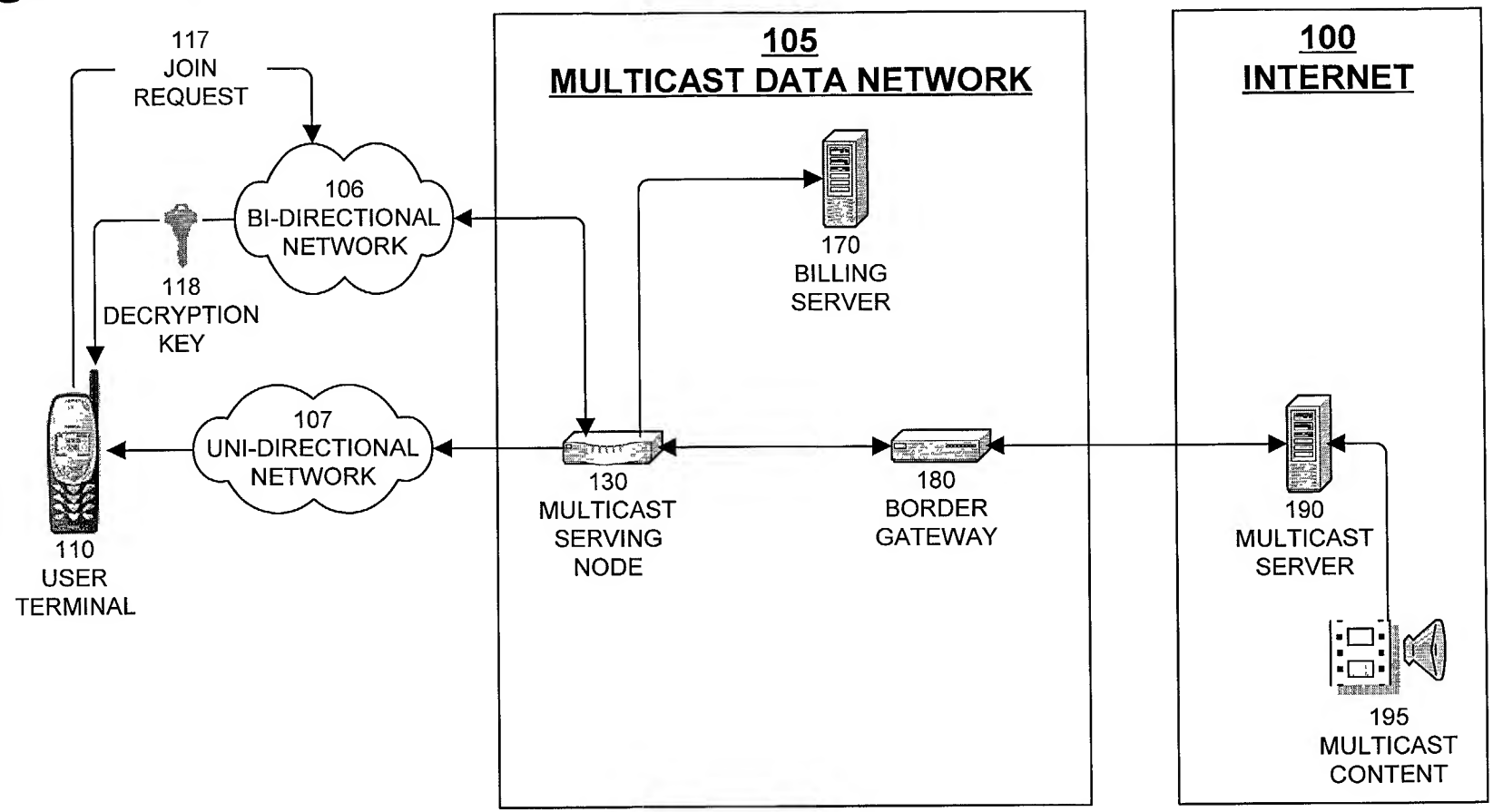

117
JOIN
REQUEST
106
BI-DIRECTIONAL
NETWORK
118
DECRYPTION
KEY
107
UNI-DIRECTIONAL
NETWORK
110
USER
TERMINAL
105
MULTICAST DATA NETWORK
170
BILLING
SERVER
130
MULTICAST
SERVING
NODE
180
BORDER
GATEWAY
100
INTERNET
190
MULTICAST
SERVER
195
MULTICAST
CONTENT

Figure 1D

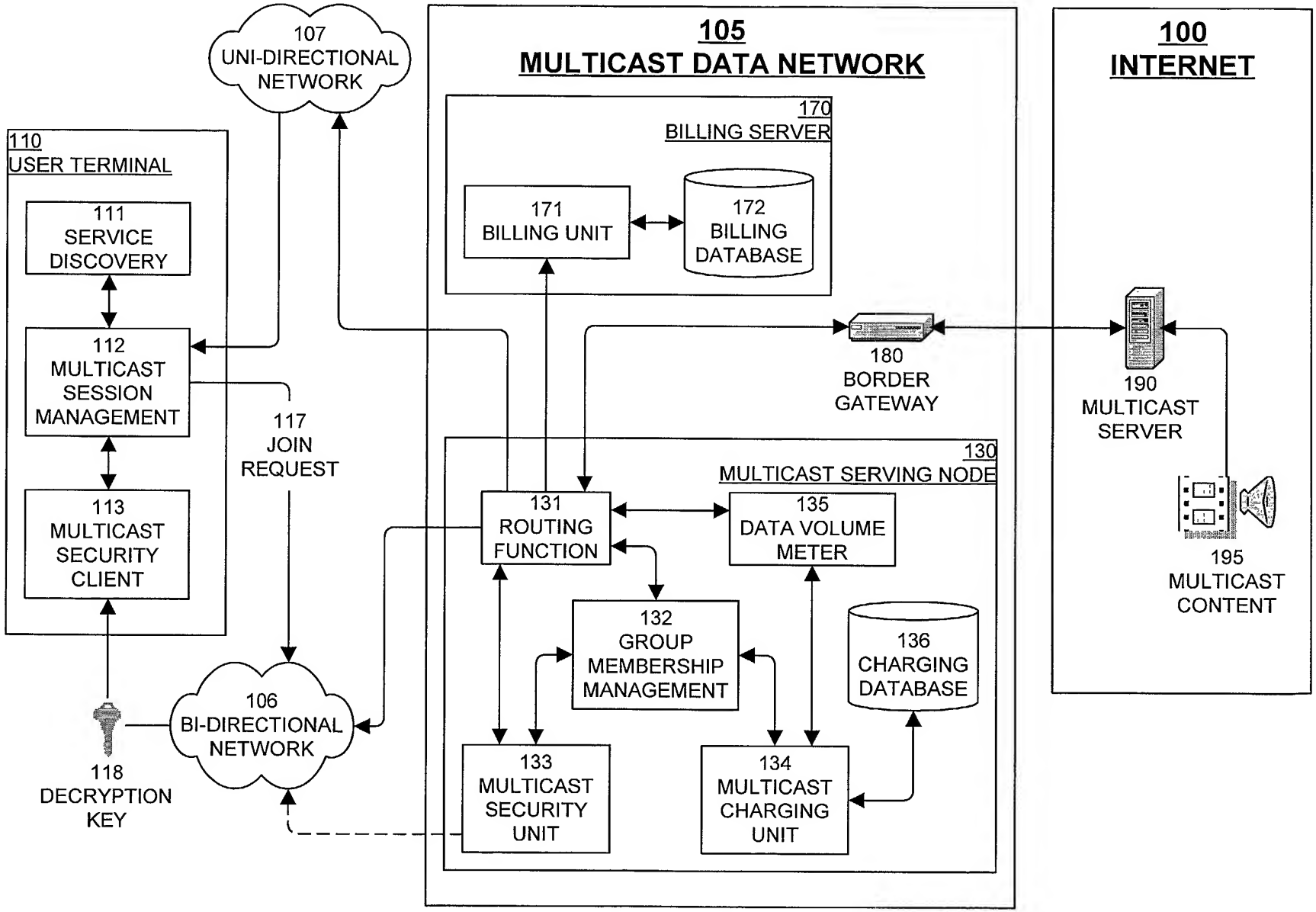

107
UNI-DIRECTIONAL
NETWORK
105
MULTICAST DATA NETWORK
100
INTERNET
170
BILLING SERVER
171
BILLING UNIT
172
BILLING
DATABASE
110
USER TERMINAL
111
SERVICE
DISCOVERY
112
MULTICAST
SESSION
MANAGEMENT
113
MULTICAST
SECURITY
CLIENT
117
JOIN
REQUEST
180
BORDER
GATEWAY
190
MULTICAST
SERVER
195
MULTICAST
CONTENT
130
MULTICAST SERVING NODE
131
ROUTING
FUNCTION
135
DATA VOLUME
METER
132
GROUP
MEMBERSHIP
MANAGEMENT
136
CHARGING
DATABASE
106
BI-DIRECTIONAL
NETWORK
118
DECRYPTION
KEY
133
MULTICAST
SECURITY
UNIT
134
MULTICAST
CHARGING
UNIT

Figure 1E

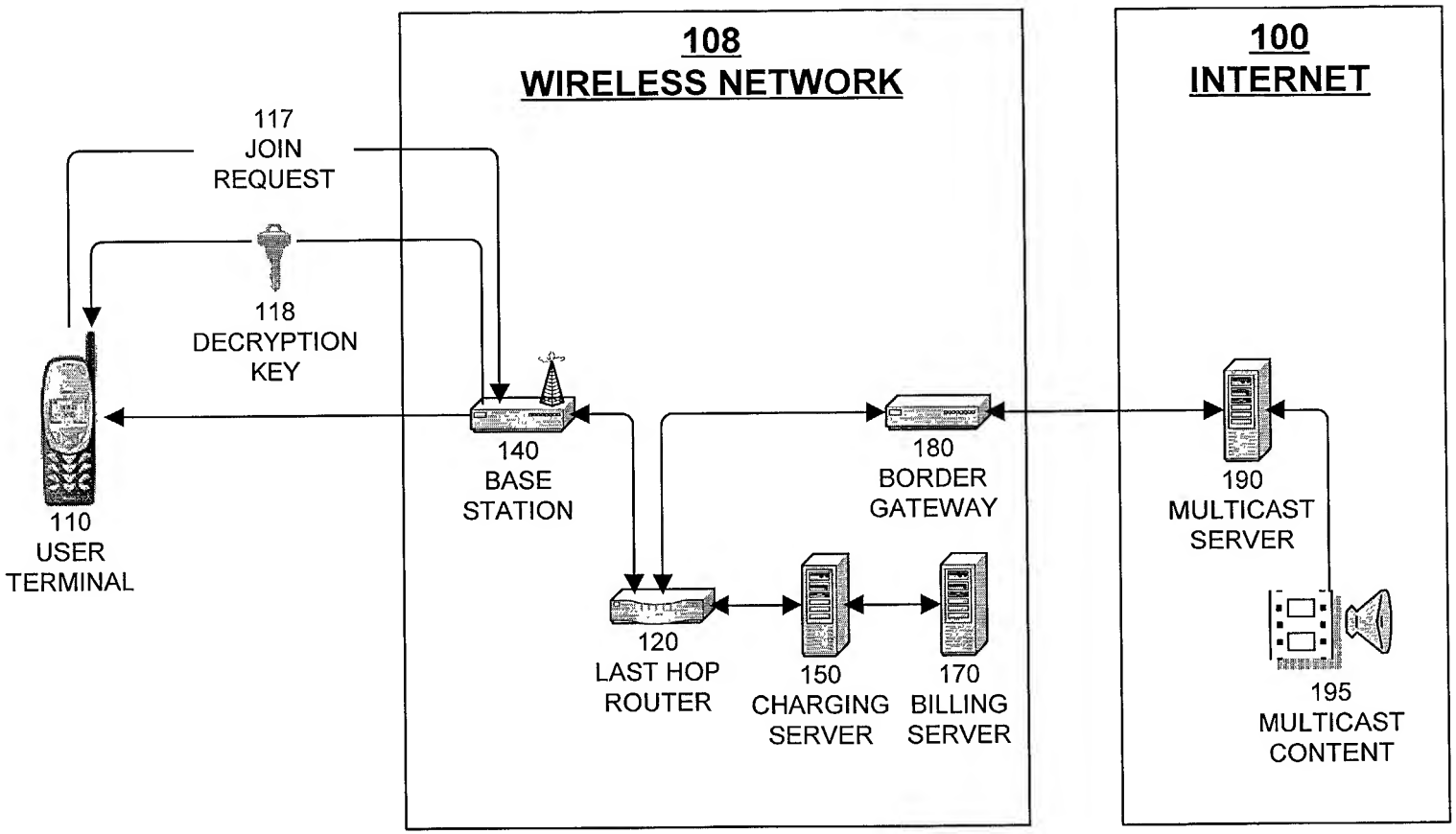

108
WIRELESS NETWORK
100
INTERNET
117
JOIN
REQUEST
118
DECRYPTION
KEY
110
USER
TERMINAL
140
BASE
STATION
180
BORDER
GATEWAY
190
MULTICAST
SERVER
120
LAST HOP
ROUTER
150
CHARGING
SERVER
170
BILLING
SERVER
195
MULTICAST
CONTENT

Figure 1F

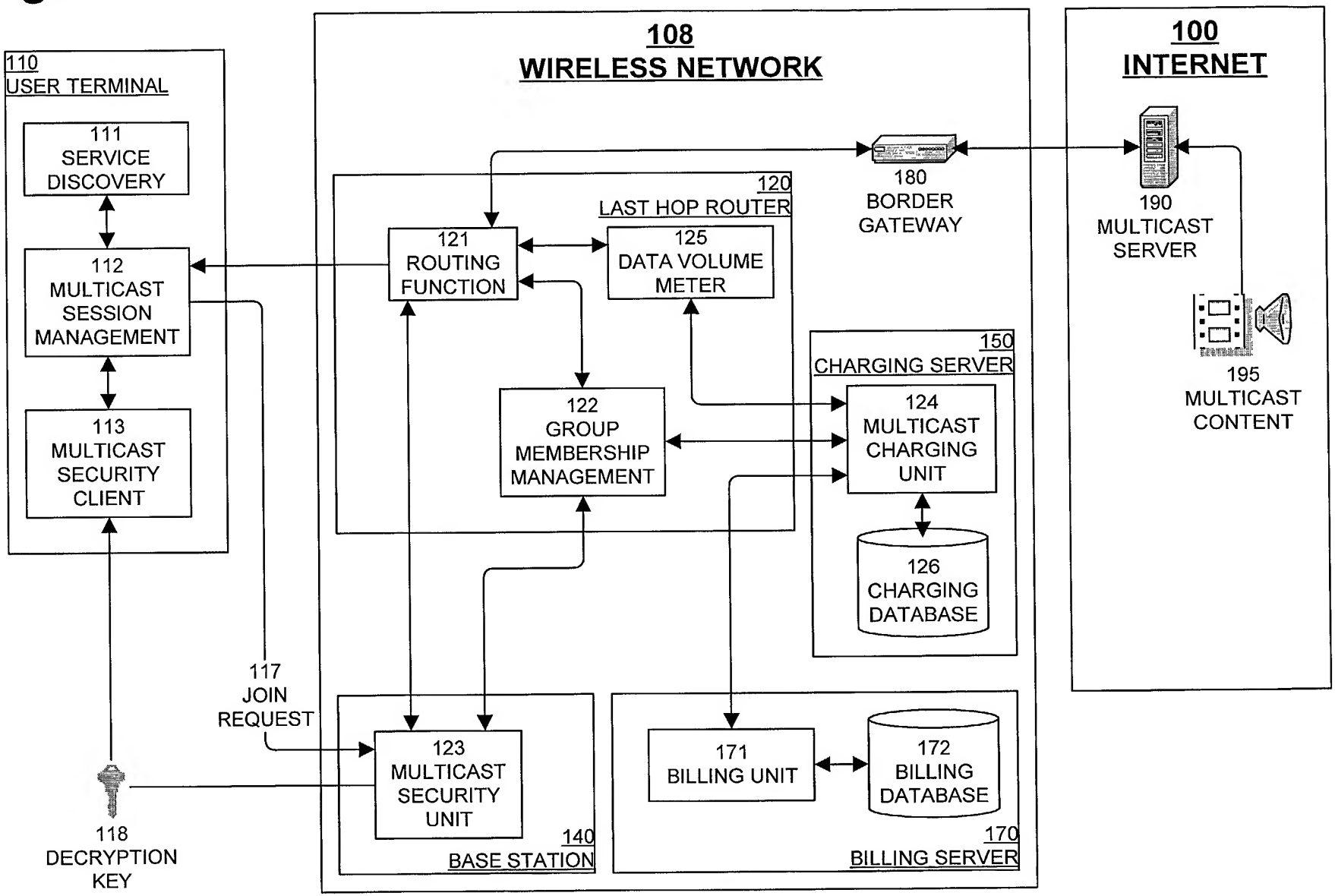

108
WIRELESS NETWORK
100
INTERNET
110
USER TERMINAL
111
SERVICE
DISCOVERY
112
MULTICAST
SESSION
MANAGEMENT
113
MULTICAST
SECURITY
CLIENT
120
LAST HOP ROUTER
121
ROUTING
FUNCTION
125
DATA VOLUME
METER
122
GROUP
MEMBERSHIP
MANAGEMENT
150
CHARGING SERVER
124
MULTICAST
CHARGING
UNIT
126
CHARGING
DATABASE
180
BORDER
GATEWAY
190
MULTICAST
SERVER
195
MULTICAST
CONTENT
117
JOIN
REQUEST
123
MULTICAST
SECURITY
UNIT
140
BASE STATION
171
BILLING UNIT
172
BILLING
DATABASE
170
BILLING SERVER
118
DECRYPTION
KEY

Figure 1G

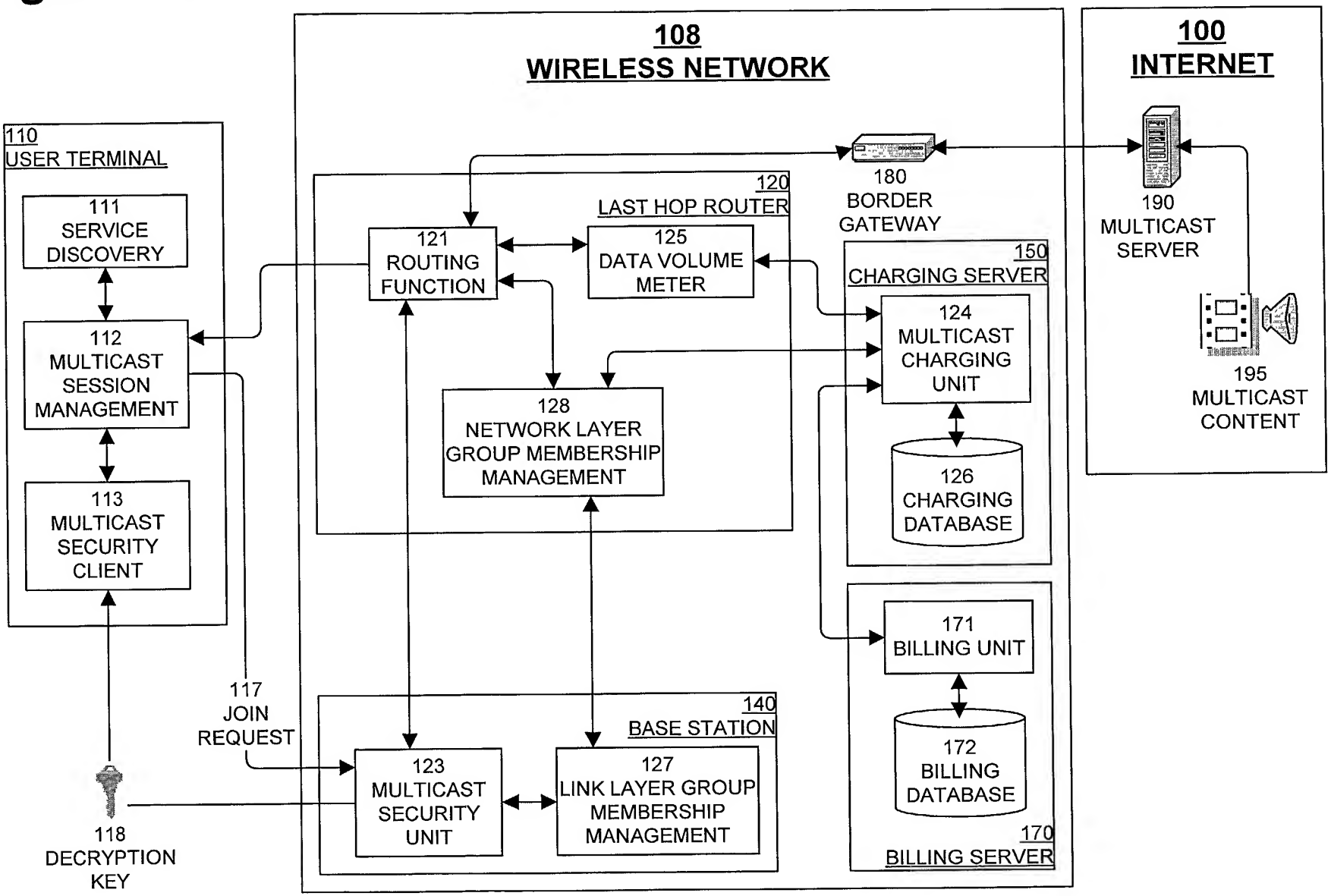

108
WIRELESS NETWORK
100
INTERNET
110
USER TERMINAL
111
SERVICE
DISCOVERY
112
MULTICAST
SESSION
MANAGEMENT
113
MULTICAST
SECURITY
CLIENT
118
DECRYPTION
KEY
117
JOIN
REQUEST
120
LAST HOP ROUTER
121
ROUTING
FUNCTION
125
DATA VOLUME
METER
128
NETWORK LAYER
GROUP MEMBERSHIP
MANAGEMENT
140
BASE STATION
123
MULTICAST
SECURITY
UNIT
127
LINK LAYER GROUP
MEMBERSHIP
MANAGEMENT
180
BORDER
GATEWAY
150
CHARGING SERVER
124
MULTICAST
CHARGING
UNIT
126
CHARGING
DATABASE
171
BILLING UNIT
172
BILLING
DATABASE
170
BILLING SERVER
190
MULTICAST
SERVER
195
MULTICAST
CONTENT

Figure 2A

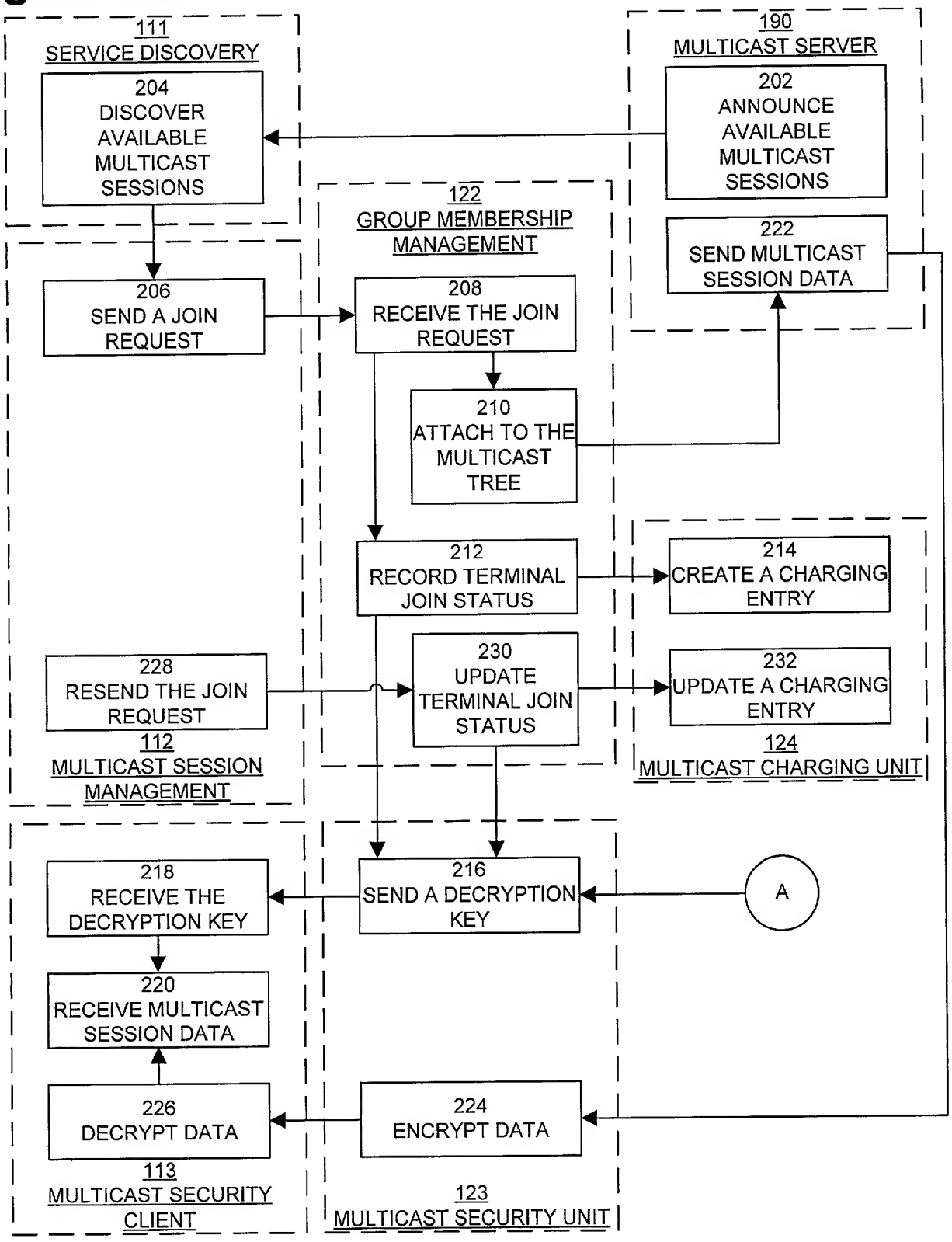

111
SERVICE DISCOVERY
204
DISCOVER AVAILABLE MULTICAST SESSIONS
190
MULTICAST SERVER
202
ANNOUNCE AVAILABLE MULTICAST SESSIONS
122
GROUP MEMBERSHIP MANAGEMENT
222
SEND MULTICAST SESSION DATA
206
SEND A JOIN REQUEST
208
RECEIVE THE JOIN REQUEST
210
ATTACH TO THE MULTICAST TREE
212
RECORD TERMINAL JOIN STATUS
214
CREATE A CHARGING ENTRY
228
RESEND THE JOIN REQUEST
230
UPDATE TERMINAL JOIN STATUS
232
UPDATE A CHARGING ENTRY
112
MULTICAST SESSION MANAGEMENT
124
MULTICAST CHARGING UNIT
218
RECEIVE THE DECRYPTION KEY
216
SEND A DECRYPTION KEY
A
220
RECEIVE MULTICAST SESSION DATA
226
DECRYPT DATA
224
ENCRYPT DATA
113
MULTICAST SECURITY CLIENT
123
MULTICAST SECURITY UNIT

Figure 2B

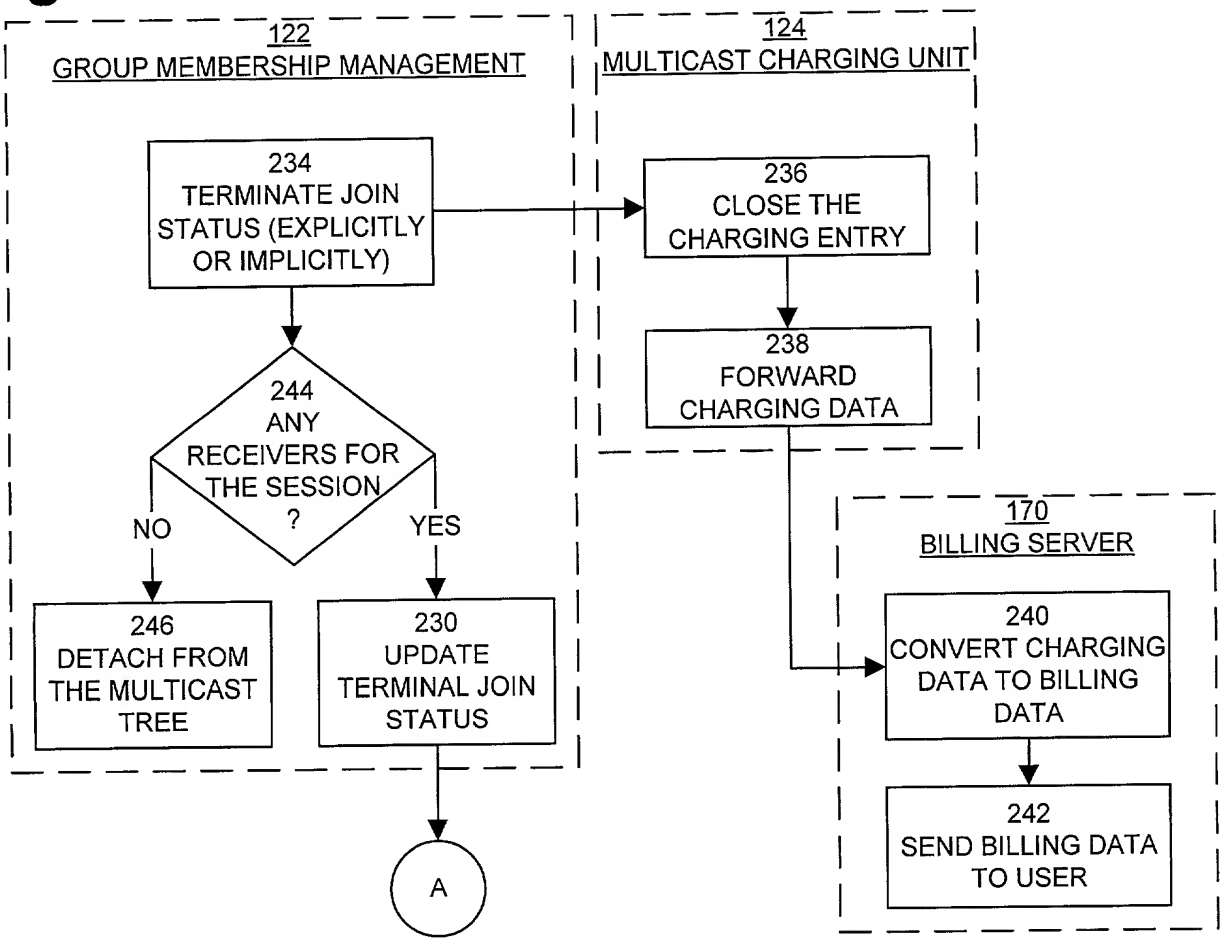

122
GROUP MEMBERSHIP MANAGEMENT
124
MULTICAST CHARGING UNIT
234
TERMINATE JOIN STATUS (EXPLICITLY OR IMPLICITLY)
236
CLOSE THE CHARGING ENTRY
238
FORWARD CHARGING DATA
244
ANY RECEIVERS FOR THE SESSION ?
NO
YES
246
DETACH FROM THE MULTICAST TREE
230
UPDATE TERMINAL JOIN STATUS
A
170
BILLING SERVER
240
CONVERT CHARGING DATA TO BILLING DATA
242
SEND BILLING DATA TO USER

Figure 2C

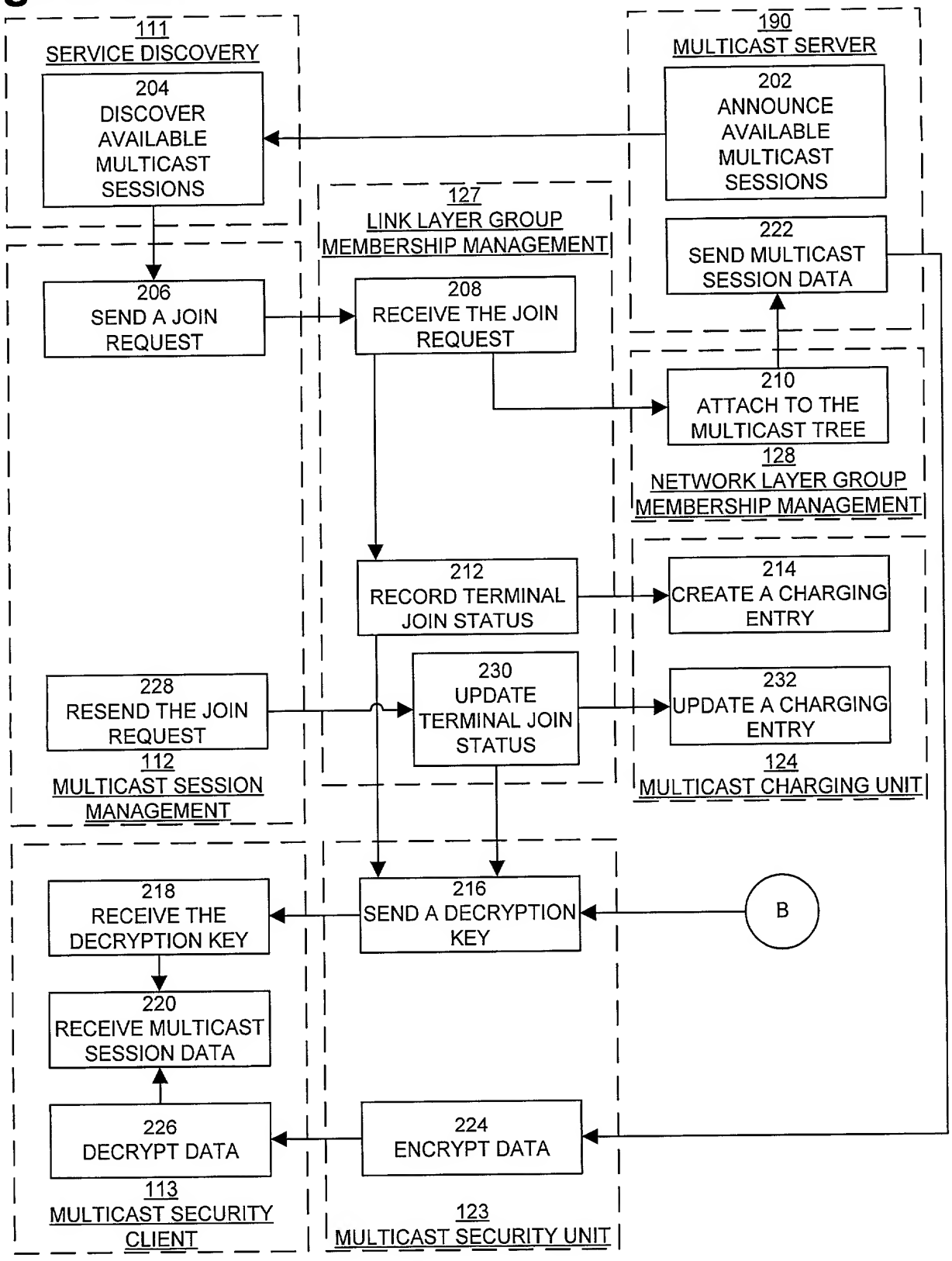

111
SERVICE DISCOVERY
204
DISCOVER AVAILABLE MULTICAST SESSIONS
206
SEND A JOIN REQUEST
190
MULTICAST SERVER
202
ANNOUNCE AVAILABLE MULTICAST SESSIONS
222
SEND MULTICAST SESSION DATA
127
LINK LAYER GROUP MEMBERSHIP MANAGEMENT
208
RECEIVE THE JOIN REQUEST
210
ATTACH TO THE MULTICAST TREE
128
NETWORK LAYER GROUP MEMBERSHIP MANAGEMENT
212
RECORD TERMINAL JOIN STATUS
214
CREATE A CHARGING ENTRY
228
RESEND THE JOIN REQUEST
230
UPDATE TERMINAL JOIN STATUS
232
UPDATE A CHARGING ENTRY
112
MULTICAST SESSION MANAGEMENT
124
MULTICAST CHARGING UNIT
218
RECEIVE THE DECRYPTION KEY
216
SEND A DECRYPTION KEY
B
220
RECEIVE MULTICAST SESSION DATA
226
DECRYPT DATA
224
ENCRYPT DATA
113
MULTICAST SECURITY CLIENT
123
MULTICAST SECURITY UNIT

Figure 2D

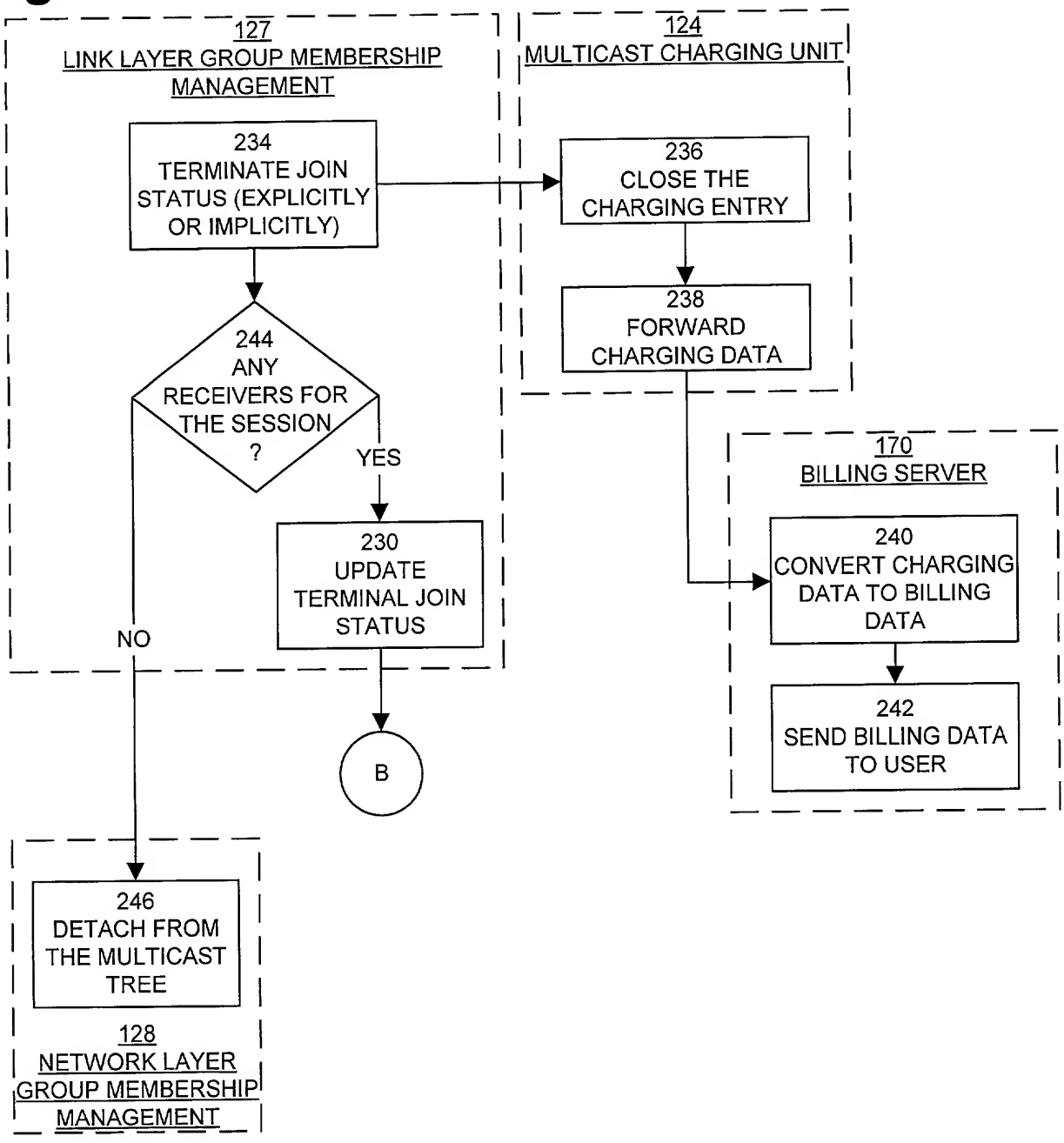

127
LINK LAYER GROUP MEMBERSHIP MANAGEMENT
234
TERMINATE JOIN STATUS (EXPLICITLY OR IMPLICITLY)
244
ANY RECEIVERS FOR THE SESSION ?
YES
NO
230
UPDATE TERMINAL JOIN STATUS
B
124
MULTICAST CHARGING UNIT
236
CLOSE THE CHARGING ENTRY
238
FORWARD CHARGING DATA
170
BILLING SERVER
240
CONVERT CHARGING DATA TO BILLING DATA
242
SEND BILLING DATA TO USER
246
DETACH FROM THE MULTICAST TREE
128
NETWORK LAYER GROUP MEMBERSHIP MANAGEMENT

Figure 3A

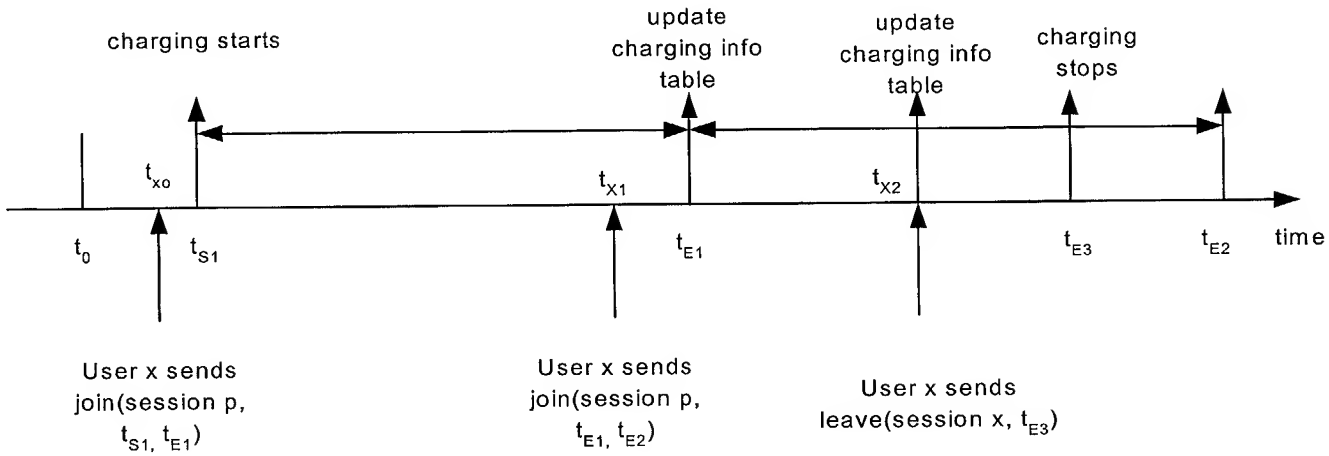

charging starts
update charging info table
update charging info table
charging stops
t_{xo}
t_{X1}
t_{X2}
t_0
t_{S1}
t_{E1}
t_{E3}
t_{E2}
time
User x sends join(session p, t_{S1}, t_{E1})
User x sends join(session p, t_{E1}, t_{E2})
User x sends leave(session x, t_{E3})

Figure 3B

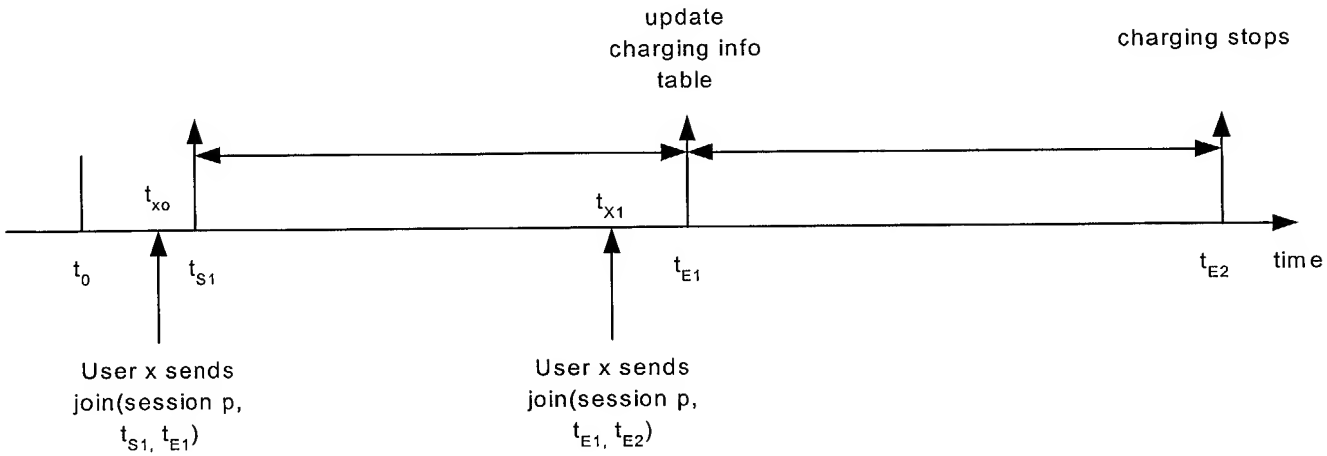

update
charging info
table
charging stops
t_{xo}
t_{X1}
t_0
t_{S1}
t_{E1}
t_{E2}
time
User x sends
join(session p,
t_{S1}, t_{E1})
User x sends
join(session p,
t_{E1}, t_{E2})

Figure 3C

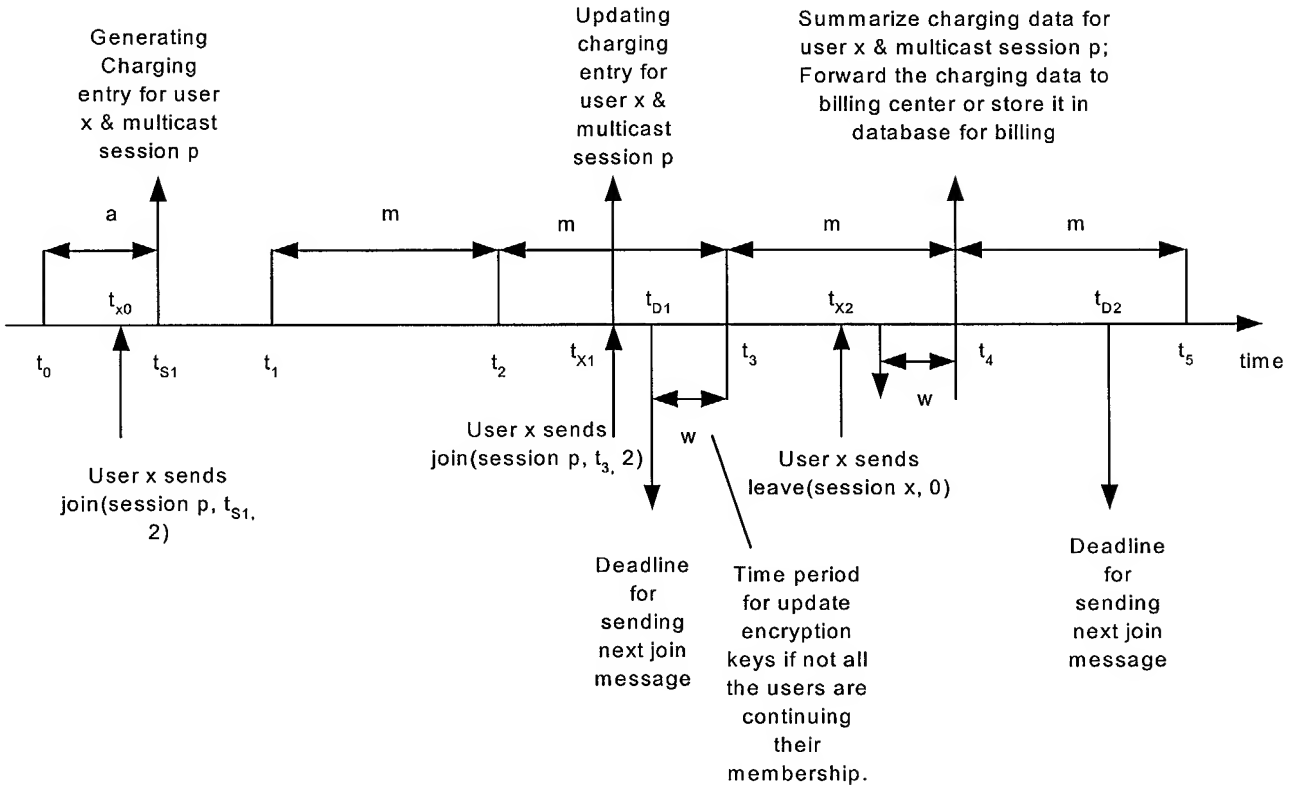

Generating Charging entry for user x & multicast session p
Updating charging entry for user x & multicast session p
Summarize charging data for user x & multicast session p; Forward the charging data to billing center or store it in database for billing
a
m
m
m
m
t_{x0}
t_{D1}
t_{X2}
t_{D2}
t_0
t_{S1}
t_1
t_2
t_{X1}
t_3
t_4
t_5
time
w
w
User x sends join(session p, t_{S1}, 2)
User x sends join(session p, t_3, 2)
User x sends leave(session x, 0)
Deadline for sending next join message
Time period for update encryption keys if not all the users are continuing their membership.
Deadline for sending next join message

Figure 3D

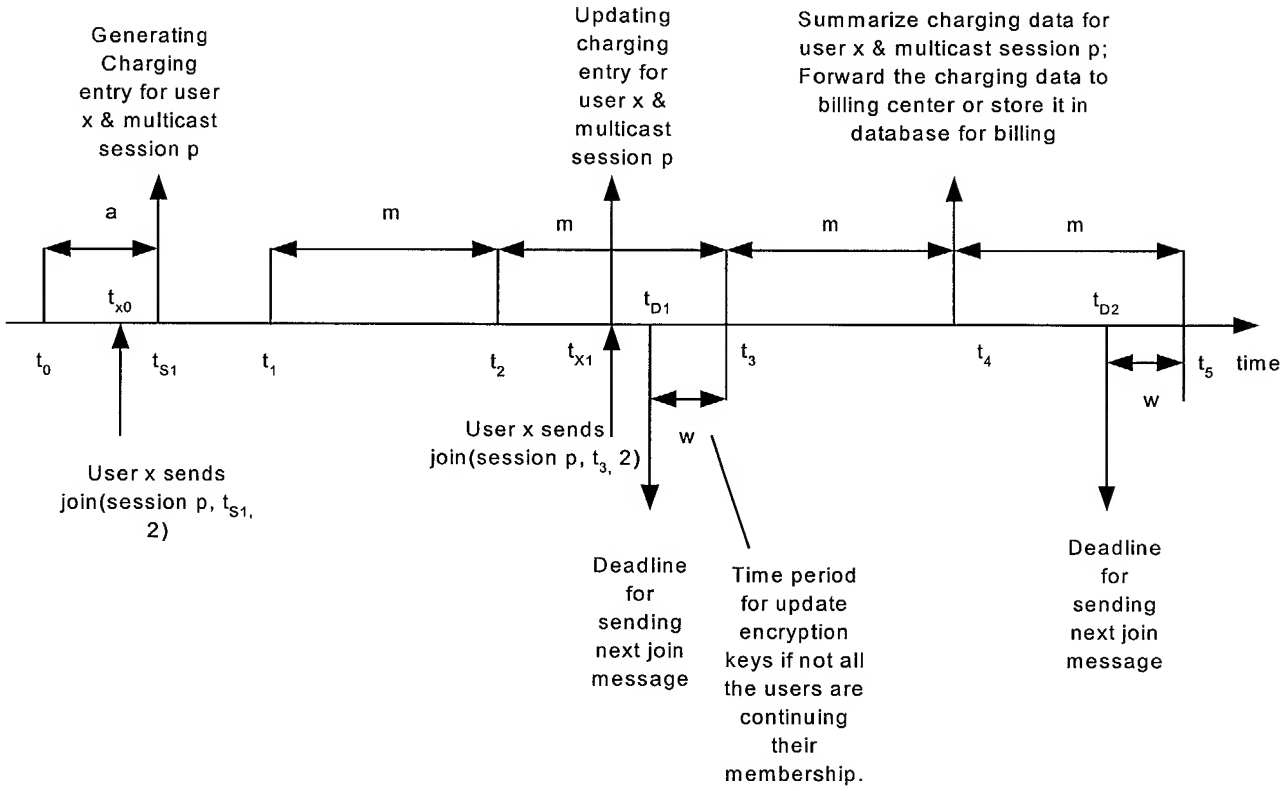

Generating Charging entry for user x & multicast session p
Updating charging entry for user x & multicast session p
Summarize charging data for user x & multicast session p; Forward the charging data to billing center or store it in database for billing
a
m
m
m
m
t_{x0}
t_{D1}
t_{D2}
t_0
t_{S1}
t_1
t_2
t_{X1}
t_3
t_4
t_5
time
w
w
User x sends join(session p, t_{S1}, 2)
User x sends join(session p, t_3, 2)
Deadline for sending next join message
Time period for update encryption keys if not all the users are continuing their membership.
Deadline for sending next join message

Figure 4A

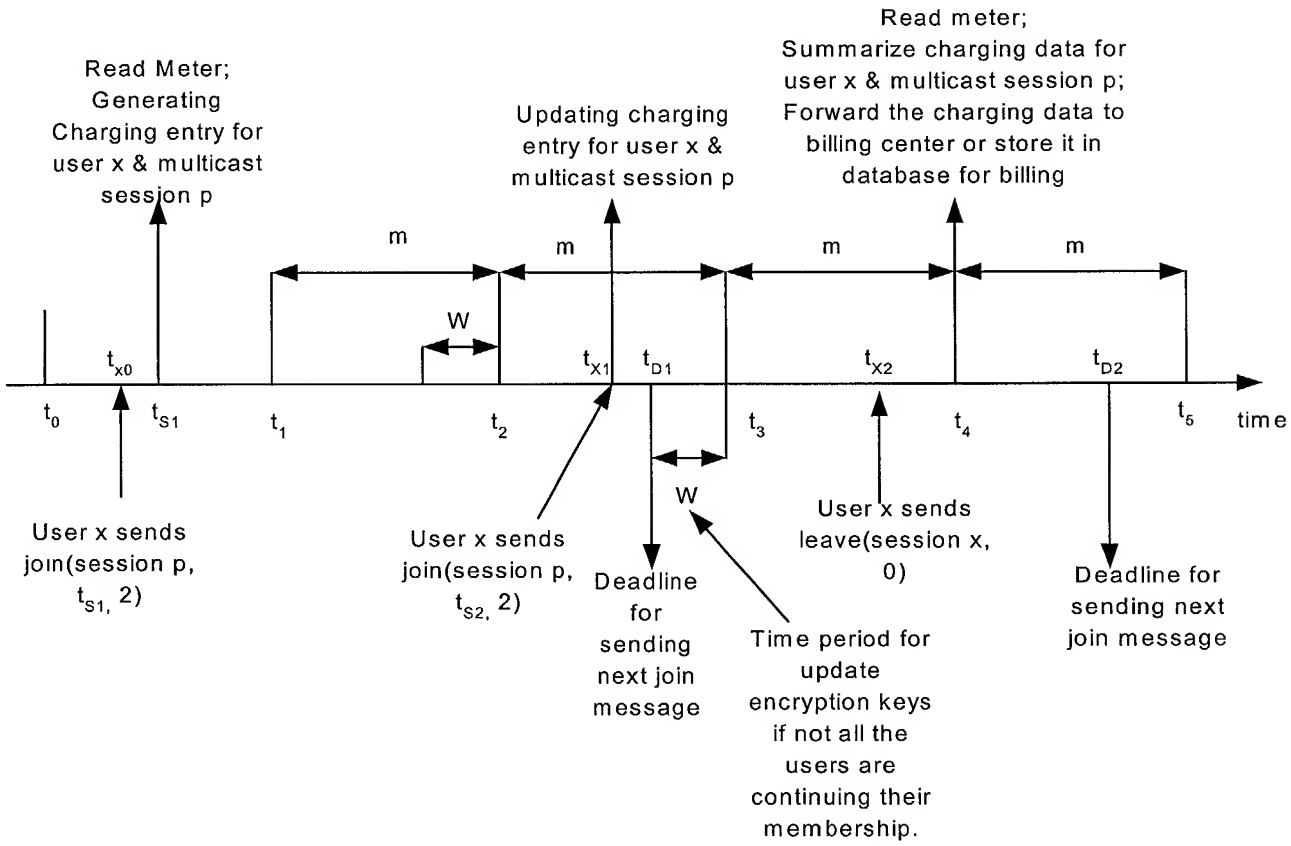
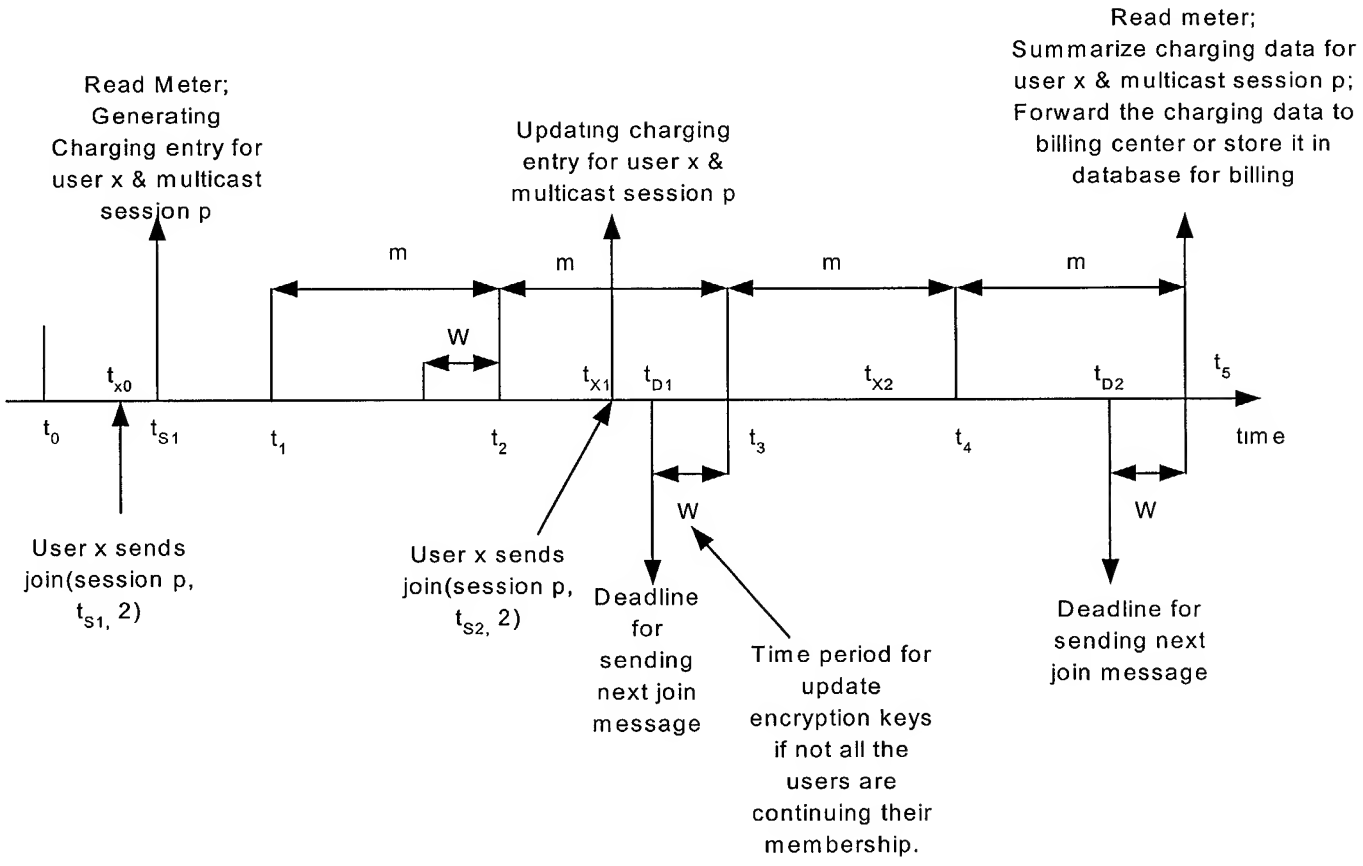

Read Meter; Generating Charging entry for user x & multicast session p
Updating charging entry for user x & multicast session p
Read meter; Summarize charging data for user x & multicast session p; Forward the charging data to billing center or store it in database for billing
m
m
m
m
W
t_{x0}
t_{X1}
t_{D1}
t_{X2}
t_{D2}
t_0
t_{S1}
t_1
t_2
t_3
t_4
t_5
time
W
User x sends join(session p, t_{S1}, 2)
User x sends join(session p, t_{S2}, 2)
Deadline for sending next join message
Time period for update encryption keys if not all the users are continuing their membership.
User x sends leave(session x, 0)
Deadline for sending next join message

Figure 4B


Read meter;
Summarize charging data for user x & multicast session p;
Forward the charging data to billing center or store it in database for billing
Read Meter;
Generating Charging entry for user x & multicast session p
Updating charging entry for user x & multicast session p
m
m
m
m
W
t_{x0}
t_{X1}
t_{D1}
t_{X2}
t_{D2}
t_5
t_0
t_{S1}
t_1
t_2
t_3
t_4
time
W
W
User x sends join(session p, $t_{S1,}$ 2)
User x sends join(session p, $t_{S2,}$ 2)
Deadline for sending next join message
Time period for update encryption keys if not all the users are continuing their membership.
Deadline for sending next join message